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European Patent Office
Office européen des brevets

(19)

(11) Publication number: **0 611 941 A2**

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **94200302.1**

(22) Date of filing: **03.02.94**

(51) Int. Cl.[5]: **F28D 9/00**, F28F 3/04

(30) Priority: **19.02.93 IT MI930323**

(43) Date of publication of application:
24.08.94 Bulletin 94/34

(84) Designated Contracting States:
BE CH DE ES FR GB IT LI NL SE

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(54) A plate-type heat exchanger and related plates.

(57) A plate-type heat exchanger for liquids comprising a plurality of ribbed plates of a first (1,51) and a second (21,62) type which are alternately juxtaposed to form flow chambers of a first and a second type, some ribs (10,11,12,13,52,53,54,55) of the plates of the first type (1,51) forming, in the chambers of the first type, a meander flow path duct in the plane of the plates having a length which far exceeds the dimensions of the plates (1,21,51,62) and the length of the flow chambers of the second type.

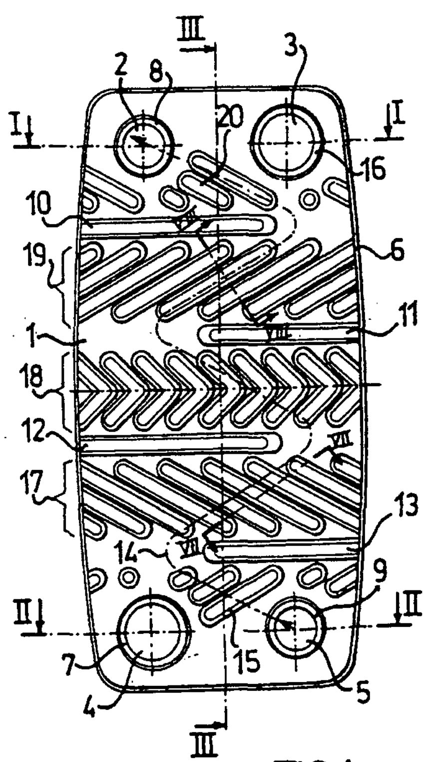

FIG.1

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The present invention relates to a plate-type heat exchanger for liquids, specifically water, being of the type which is used in so-called compound boilers used at one time for space heating and dispensing heated water.

It also relates to the heat exchanging plates forming such exchangers.

It is known that in compound systems, a boiler is arranged to heat the water in a closed primary circuit, which water is circulated, usually by means of low-head pumps, through the heating system and simultaneously supplied to the primary branch of a heat exchanger having a secondary branch connected to the water supply.

The output of the secondary branch is connected to the home hot-water distribution network.

A heat exchanger for such an application is to meet several conflicting requirements:

it should be quite compact, possess high exchange efficiency, and produce limited pressure drops, especially across the primary circuit.

In addition, it should ensure, especially in the secondary or sanitary" circuit, because intended for delivering drinking water, a liquid flow which is as uniform as possible and can ensure an evenly distributed formation of calcareous deposits, as are unavoidable or only avoidable through the use of expensive softening equipment.

The liquid flow through the sanitary circuit is to also ensure effective and full removal of scale on the occasion of periodical servicing, that should desirably be kept to a minimum.

Plate heat exchangers have been known for this kind of application which are formed by a plurality of identical plates juxtaposed and attached to one another to form a bank of chambers consisting of first and second sets of adjacent chambers to one another, with the chambers of one set being communicated together through two sets of input and output openings, respectively, and with each chamber in the first set intervening between two chambers in the second set excepting the end chambers in the bank.

The plates are generally rectangular in shape, designed for upright installation, and have a plurality of raised ribs on the plate face, which ribs are formed by deep drawing and generally arranged in a chevron pattern along the direction of greater length or in a diagonal pattern.

The plates, which are identical with one another, are juxtaposed to one another with the rib elevation pointing in the same direction throughout, but the chevron pattern pointing alternately in one and the opposite directions.

Thus, chambers are obtained which are identical with one another and formed by two parallel walls held apart by the rib height, the tips of the ribs bearing on an adjacent plate in a discontinuous fashion broken at the crossovers of the ribs located on opposite walls.

The ribs form a plurality of V-shaped channels communicated to one another at the crossovers with opposite ribs to produce a grid-like labyrinth which provides a flow path in a direction generally corresponding to the symmetry axis of the V-shaped ribs for a liquid admitted into the chambers.

The ribs perform multiple functions: additionally to stiffening the plates, which should be made thin for a good heat transfer, consistent with the requirements of operation under a pressure, they are effective to increase the transfer area, somewhat spread the flow over the entire chamber cross-section, and induce a turbulent motion in the liquid admitted into the exchanger, which ensures good transfer efficiency.

Exchangers of this type are beset with drawbacks and inherent limitations which have limited their spreading.

With the chambers formed by the plates being identical, the two hydraulic circuits formed by the exchanger, which only differ by the size of the liquid inlet/outlet opening, are identical and present the same outflow cross-section.

For a given flow rate, they produce the same pressure drops.

In a condition of different flow rates, with the flow in the primary circuit being the larger, as is normally the case with such exchangers, considerable pressure drops occur across the primary circuit which are larger than across the secondary circuit.

For example, across an exchanger having dimensions in the range of 80 x 180 x 35 mm and including 12 chambers with a flow rate of 1300 l/h across the primary, the pressure drop would be about 0.5 bar, and with a corresponding flow rate of 600 l/h through the sanitary circuit, the pressure drop across the sanitary circuit would be about 0.22 bar.

Whereas the pressure drop across the sanitary circuit is negligible compared to the normal conditions of water supply from the distribution network (3 to 6 bar), the pressure drop across the primary is specially troublesome and cost-intensive and requires that circulation pumps of adequate head and power be used in the primary.

Further, the dimensions specified for the exchanger bring out a second important criticalness.

Assuming for the thickness of the plates, made of stainless steel, an illustrative value of 0.4 mm, the thickness of the chambers, i.e. the free distance between plates, would be in the 2 to 3 mm range.

The formation of calcareous deposits over the walls of the sanitary circuit not only reduces trans-

fer efficiency quite significantly but may result in the circuit being partly and selectively occluded in dependence on an uneven distribution of the flow through the exchanger being augmented by scale and quickly resulting in an inefficient exchanger.

Treating the exchanger with an acid to descale it is made difficult by that even in this case the acid flow tends to act on the paths of easiest passage, leaving dead pockets of unremoved scale.

These limitations are obviated by the plate-type heat exchanger of this invention, wherein a high transfer efficiency is ensured by a primary circuit exhibiting low pressure drops and a secondary circuit of increased length having a constrained flow path which is smooth and free of stagnation areas and ensures reduced formation of calcareous deposit, longer service life and more effective service interventions.

These results are obtained by the plate-type heat exchanger of this invention being implemented with two different types of juxtaposed plates, a first type being provided with raised ribs intended to contact a flat surface of a plate of the second type to form a first type of labyrinth chamber which ensures a fixed path for the flow through the sanitary circuit with greater length and smaller cross-section than the primary circuit, while by placing a plate of the second type next to that of the first type, on the opposite face from that with the raised ribs, a second type of chamber is formed which ensures increased flow-through cross-section and decreased flow path length for the primary circuit flow.

Both plate types are provided with a second plurality of ribs intended for juxtaposition, preferably but not necessarily with the same orientation, which increase the transfer area to form a labyrinth across a perpendicular cross-section to the plane of the plates which ensures a flow cross-section with no abrupt changes, and hence with no major pressure drops either in the primary or the secondary circuit, while still generating the required turbulent flow due to the change in direction imparted to the flow.

According to a further aspect of the present invention, the second plurality of ribs comprise at least two sets of ribs, a first set of ribs which extend along a transverse direction to the flow direction through the labyrinth of the first chamber type, and a second set of ribs which extend along the flow direction through the labyrinth of the first chamber type.

The first set of ribs is arranged proximate to the inlet of the sanitary circuit and cause, in relation to a corresponding sanitary outlet section of equal length, greater turbolence which enhances the efficiency of heat transfer in the exchanger area with the largest temperature differential, for a modest increase in the overall pressure drop due to uneven distribution of the load losses.

According to a further aspect of the present invention, the plates, of generic rectangular shape, have a rim or frame whose sides of grater lenght at least are slighty convex.

Preferably all the sides are convex and radiused each to the other and suitably slanted as to the plane of the plate, so as to form a conoidal surface, rather than pyramidal.

This surface provides a precise matching among plates and assures a perfect brazing of the plates among them.

According to a further aspect of the present invention the arrangement, in the two plate types, of the several sets of ribs of the second plurality is set so as to leave between adjacent sets a flat zone or portion of the plate, each provided or not with a rib of the first plurality.

By this arrangement the two plate types can be combined to obtain a whole family of heat exchangers having differing features and performances, suitable for differing applications and meeting differing requirements.

The features and advantages of the invention will be more clearly apparent from the following description of a preferred embodiment of the invention, and from the accompanying drawings, in which:

Figure 1 is a front view of a plate of a first type used in the making of a heat exchanger according to this invention;

Figure 2 is a cross-section along I-I in Figure 1 of the plate of Figure 1;

Figure 3 is a cross-section along II-II in Figure 1 of the same plate;

Figure 4 is a cross-section along III-III in Figure 1 of the same plate;

Figure 5 is a front view of a plate of a second type used in the making of a heat exchanger according to this invention;

Figure 6 is a cross-section along IV-IV in Figure 5 of the plate of Figure 5;

Figure 7 is a cross-section along V-V in Figure 5 of the same plate;

Figure 8 is a cross-section along VI-VI in Figure 5 of the same plate;

Figure 9 is a cross-section along I-I in Figure 1 and IV-IV in Figure 5 of an exchanger made by alternately juxtaposing plates of the first and second types;

Figure 10 is a cross-section along II-II in Figure 1 and V-V in Figure 5 of the exchanger of Figure 9;

Figure 11 is a cross-section along III-III in Figure 1 and VI-VI in Figure 5 of the exchanger of Figure 9;

Figure 12 is a view taken in the plane VII-VII in Figure 1 of a section of the flow channel formed by superimposing a plate of the second type on a plate of the first type, as cut away along the flow direction;

Figure 13 is a sectional view taken in the plane VIII-VIII in Figure 1 across the flow direction showing a section of the flow channel formed by superimposing a plate of the second type on a plate of the first type; and

Figure 14 is a space vs.temperature diagram of the behavior of a heat exchanger.

Figure 15 is a front view of an alternative embodiment for the plate of the first type.

Figure 16 is a front view of an alternative embodiment for the plate of the second type.

With reference to Figures 1 to 4, a first plate type 1 consists of an element, generally rectangular in shape (more properly, according to an aspect of the invention, having convex sides, at least the longer ones, which has four circular openings 2, 3, 4, 5 arranged proximate to the apices of the rectangle, and a slightly cone-shaped rim or frame 6 deep drawn from a flat sheet, preferably of stainless steel, from which the plate is formed.

Also deep drawn from the plate 1 are two bearing collars 16, 7, raised with reference to the view of Figure 1, which respectively surround the openings 3 and 4, and two recessed bearing collars 8, 9 which respectively surrounds the openings 2, 5. These aspects of the plate of Figure 1 are conventional and known.

According to the invention, the plate 1 is also provided with a first plurality of straight parallel ribs 10, 11, 12, 13 extending crosswise to the direction of greater spread of the plate 1, and therefore, horizontal in Figure 1.

The ribs, being raised above the plate surface as viewed in Figure 1, are alternately offset from one another, with one end in contact with opposite walls of the frame 6 and the other end away from the frame.

It can be appreciated that, on laying a flat surface onto the ribs 10, 11, 12, 13, with the surface spanning the full width of the plate 1, a labyrinth or more properly a meander path will be created which extends in the plane of the plate and is schematically indicated by the dash line 14.

This meander constitutes a flow passage for a liquid admitted into the labyrinth, such as through the opening 5, and discharged through the opening 2.

The flow passage has a much greater length than the height of the plate, and an outflow cross-section which is defined by the height of the ribs 10, 11, 12, 13 and their mutual spacing.

The plate 1 is also provided, additionally to the first plurality of ribs 10, 11, 12, 13, with a second plurality of ribs, which are also raised from the plate plane and have preferably, but not necessarily, a smaller height than the ribs of the first plurality.

The ribs, being generally elongate and laid parallel to one another, are collectively denoted as sets thereof by the references 15, 17, 18, 19, 20, and as clearly shown in Figure 1, arranged in the outflow channel defined by the ribs 10, 11, 12, 13 along a variable direction with respect to the main direction of a liquid flow through the channel.

In particular, the ribs 15, 17 are elongate and arranged crosswise to the flow direction, the ribs 19, 20 are elongate and arranged substantially along the flow direction, and the V-shaped ribs 18 are arranged partly along the flow direction and partly across it.

Basically, the second plurality of ribs serve, as explained hereinafter, the dual function of increasing the area of heat transfer between two fluids separated by the plate 1, and of producing a convenient turbulence in the flows of the two fluids for a more efficient transfer of heat.

Figures 5 to 8 show a second type of plate 21 of the heat exchanger according to the invention.

The plate 21, having a generally rectangular shape identical with that of the plate 1, is also provided with four openings 22, 23, 24, 25 identical with the openings 2, 3, 4, 5 in the plate 1 and arranged in the same pattern, a drawn rim 26 identical with the rim 6, and bearing collars 27, 28, 29, 30 which surround the homologous openings 22, 23, 24, 25 of the openings 2, 3, 4, 5, respectively.

Unlike the collars 16, 7, the homologous collars 28, 30 are recessed below the plane of the plate 21, and the collars 27, 29, being the homologs of the collars 8, 9, are raised above the plane of the plate 21.

The plate 21 is also provided with a plurality of raised ribs, identical in pattern and shape with the ribs of the second plurality of ribs on the plate 1.

These ribs are collectively denoted as sets thereof by the references 31, 32, 33, 34, 35, respectively corresponding to the sets 15, 17, 18, 19, 20.

Unlike the plate 1, the plate 21 has, between sets of ribs 31, 32, 34, 35, a continual flat surface for receiving the first plurality of ribs 10, 11, 12, 13 of the plate 1 thereon.

Alternatively, as explained hereinafter, the plate 21 may also be provided with a plurality of parallel ribs being the homologs of the ribs 10, 11,12, 13 and recessed from the plate 21 rather than raised, in this case.

The combined elevation of the collars 16, 7 of the plate 1 and depression of the collars 28, 30 of the plate 21 are equal to the height or elevation of

the ribs 10, 11, 12, 13.

Likewise, the combined depression of the collars 8, 9 of the plate 1 and elevation of the collars 27, 29 of the plate 21 are equal to the height or elevation of the ribs 10, 11, 12, 13.

It can therefore be appreciated that, as clearly illustrated by the sectional views of Figures 9, 10, 11, the superimposition of a plate as the one of Fig. 5 on a plate such as 1 of Fig. 1 results in a flattened chamber of a first type being formed which is closed peripherally by the frame 6, rearwardly (as viewed in Figures 1 and 5) by the plate 1, and forwardly by the plate of Fig.5.

The chamber can be reached through the openings 2, 22 and 5, 25, the respective collars 8, 27 and 9, 29 whereof being spaced apart from each other.

On the other hand, the collars 28, 30 of the plate 21 are brought to bear on the corresponding collars 16, 7 of the plate 1, thereby shutting off the thus formed chamber from access through the openings 3, 4 in the plate 1 or the corresponding openings 23, 24 in the plate 21.

In addition, the tops of the ribs 10, 11, 12, 13 will contact the flat surface of the plate 21 to form in the hollow the meander or flow channel described above.

In this flow channel, the sets of ribs 15, 17, 18, 19, 20, respectively juxtaposed to the sets of ribs 31, 32, 33, 34, 35, form in the flow channel a labyrinth path which extends substantially in a perpendicular plane to the plane of the plate.

Figure 12, a sectional view taken in the plane VII-VII in Figure 1, shows in cross-section a section of the flow channel proximate to the openings 5, 25 along the flow direction, and brings out that the flow Φ of a liquid admitted into the channel is subjected to continual changes of direction as directed by the ribs.

Also, the outflow cross-section is variable, being slightly narrower at the sections defined by the rib walls.

The continual changes in direction and cross-section impart considerable turbulence to the flow of the liquid admitted into the chamber.

Figure 13, a sectional view taken in the plane VIII-VIII in Figure 1, shows in cross-section a section of the flow channel proximate to the openings 2, 22 along a substantially perpendicular direction to the flow direction, and brings out that the flow Φ of a liquid admitted into the channel, at this section having a considerable heat transfer area, is subjected to no continual changes in direction or outflow cross-section.

In this region, any pressure drop of a moving fluid would be due essentially to the fluid internal viscosity and the residual fluid turbulence induced upstream.

Thus, the pressure drops would be limited.

The superimposition of a plate such as 1 on a plate such as 21 (Fig. 5) results in a chamber of a second type being formed which has radically different features.

First of all, the recessed collars 8 and 9 of the plate 1 will contact the corresponding raised collars 27, 29 on the plate 21, thereby shutting off the chamber from access through the openings 2, 22 and 5, 25.

Secondly, the raised ribs 10, 11, 12, 13 on the plate 1 form no labyrinth within the chamber but merely an expanded cross-section passageway, and the resultant chamber constitutes a substantially straight, short flow channel between the openings 3, 23 and 4, 24 to which the plate ribs impart, as shown in Figure 11, a labyrinth pattern extending in a perpendicular plane to the plane of the plates.

Here again, the labyrinth ensures increased heat transfer area and convenient turbulence for a fluid admitted into the chamber, at much more limited load losses even with large flow rates because of the much shorter length of the flow section.

It can be appreciated, therefore, that by juxtaposing a plurality of plates, alternately of the first type and the second, as illustrated by the cross-sections in Figures 9, 10, 11, duly brazed at the frame, the openings, and other contacting parts such as the ribs 10, 11, 12, 13, a plate exchanger can be provided which has two separate circuits with radically different features.

The primary circuit, being formed by chambers of the second type in parallel with one another, is characterized by extremely low pressure drops, while the secondary or sanitary circuit, formed by chambers of the first type, is characterized by pressure drops which are not much higher and a circuit length effective to ensure a highly efficient transfer of heat.

Furthermore, the constrained flow path of the secondary circuit prevents the local formation of calcareous deposit and promotes, where necessary, a more effective descaling operation by forcing the descaling chemical through the same constrained path.

The heat transfer efficiency is further enhanced, at equal pressure drops, by the peculiar arrangement of the second plurality of ribs, which restrict to some extent the generation of turbulence, and attendant load losses, to a limited region of the chambers proximate to the secondary circuit inlet and the primary circuit outlet.

Without venturing too deeply into theoretical formulations, the diagram of Figure 14 may be considered which illustrates schematically the temperature variations of the two fluids, e.g. water,

entering and exiting an exchanger in countercurrent relationship.

Shown at T1I and T2I are the inflow temperatures of the primary and the secondary fluids, respectively, and at T1U, T2U the respective outflow temperatures.

To have a temperature of the secondary fluid which closely approximates that of the primary fluid, using small size exchangers, we tend to use larger primary than secondary fluid flow rates, such that the thermal drop between the outgoing primary fluid and the incoming secondary fluid is quite large and larger than that at the outlet.

The transfer of heat will, therefore, be stronger at the inlet than at the outlet, and it is in that region that the transfer efficiency ought to be ensured to prevent a laminar flow from generating, especially at small flow rates, temperature gradients within the fluid such as would limit the heat transfer rate.

For a given amount of turbulence and attendant pressure drop, it is apparent that turbulence induced where the thermal drop is largest contributes more significantly to an efficient transfer of heat.

This is the effect achieved by the arrangement of the second plurality of ribs as described above, in sets differently oriented relative to the flow direction, thereby increasing the transfer area and simultaneously providing an uneven distribution of the pressure drops and the turbulence induced in the circuit.

As an example, an exchanger including six + six plates of the two types described above and measuring approximately 80 x 180 x 35 mm, being quite equivalent in size to conventional exchangers, for the same inflow and outflow temperature as conventional exchangers and the same secondary flow rate (600 l/h), requires a lower primary flow rate of 1000 l/h at load losses of about 0.05 bar across the primary circuit and about 0.09 bar across the secondary circuit.

It should be understood that the foregoing description only relates to a preferred embodiment of the plate-type exchanger, and that many changes may be made thereunto without departing from the invention spirit.

In particular, the plate 1 may be provided with raised ribs such as 10, 11, 12, 13 which, instead of contacting the flat surface of a plate 21 overlying it, would contact corresponding recessed ribs in the plate 21.

The height and depth of these corresponding ribs would define in this case the spacing between the juxtaposed plates and the thickness of the resultant chamber.

With this thickness should obviously conform the elevation and depression dimensions of the collars 16, 7 and 28, 29 of the plates 1 and 2, respectively.

The thickness of the chambers formed by the plates is essentially defined by the elevation and the depression of the collars, and may either be the same for both chamber types formed by the plates or be different, to adjust the average outflow cross-sections of the primary and secondary circuits for more or less different flow rates and make the pressure drops across the two circuits different.

The number of the plates and the chambers formed thereby may also be varied within a broad range to meet widely different space and capacity requirements.

It is also apparent that the connection of the exchanger thus formed to the primary and the secondary networks and the closure of the bank end plates are conventional and may be provided in a conventional manner.

For instance, as illustrated by the cross-sections of Figures 9 and 10, an end plate denoted by the reference 40 may be similar to the plates of the first type, such as the plate 1, but without the openings 2, 3, 4, 5, thereby shutting off as by contact and brazing the openings 23 and 24 in the adjacent plate 41 of the second type to form in combination an end chamber of the first type.

On the opposite side of the plate bank, a plate 42 may be provided, as by soldering or otherwise, with fittings 43, 44, 45, 46 for connection to inlet/outlet ducts of the primary and secondary circuits.

As a further example it may be noted that plates such as 1 an 21 may also be coupled together to form different type of chambers for the primary and secondary flow, by superimposing plates of type 1 to plates of type 21, the last one being rotated of 180° as to the position shown in fig. 5

In this way opening 2 is axially aligned with opening 25 and likewise opening 5 is aligned with opening 22.

Collar 16 is coupled to collar 30 and likewise collar 7 is coupled to collar 28.

By this arrangement of the plates an exchanger is obtained where the ribs of the second plurality overlap in crossed fashion.

By having ribs of the first and second plurality of the same height a plurality of contact points between adjacent plates is achieved.

The contat point are distributed on the plate extension and, at equal plate thickness provide a higher pressure strenght by the exchanger so formed.

With the same pair of plate types exchangers can therefore be obtained which have different performances and meet differing requirements.

In this perspective, as a further example of possible alternatives embodiments, it may be noted that the plates shown in fig 1 and fig. 5, can be

used, with minimal modifications, to manufacture a broad range of heat exchangers meeting the more differing requirements.

Figures 15 and 16 show two plates modified to this purpose.

Plate 51 of fig. 15 has a ribs and openings arrangement equivalent to the one of the plate 1 of fig. 1.

The ribs, all having equal height are of two kinds: a first kind of ribs, 52,53,54,55 extends alternately from one of the two plate side walls 155,56 having greater lenght, toward the opposite side wall, in a direction substantially perpendicular to the extension of such side walls so as to form a meander path in the plane of the path.

The ribs of the second kind are housed in this meander path. They are divided in a plurality of rib sets, the ribs in each set being parallel each to the other and extending in slanted direction as to the plate side walls of greater lenght.

Each rib set (possibly with the exception of ribs surrounding the flow input/output openings) form a band extending between opposed sidewalls of greater lenght of the plate.

In fig. 15 bands 57,58,59,60,61 in top-down order can be easily seen.

The bands are spaced apart the one from the other by a flat portion or zone of the plate which portion too extends from a side wall of greater lenght towards the opposite one, not necessarily reaching it, as shown for better understanding only.

In fig. 15 spacing portions 62,63,64,65 are shown.

These portions may be considered as extending to encompass the ribs of the first kind, 52,53,54,55.

In each band, the ribs extend obliquely with opposed slanting from band to band.

In a central band 59, where the ribs are chevron shaped, it may be observed that at least in proximity of the spacing portion 63 the ribs of band 59 have a slape opposite to the one of the ribs in adjacent band 58.

Likewise, in proximity of the spacing portion 64, the ribs of band 59 have a slape opposite to the one of the ribs in adjacent band 60.

The arrangement of ribs 52,53,54,55 (of the first type) is not exactly symmetrical relative to the center of the plate: it may be observed that while rib 52 is located within the spacing portion 62 in a position closer to the center of the plate, the rib 55 is symetrically located with an offset and a greater distance from the plate midline 66, the offset being equal to the rib width.

The same consideration can be made for ribs 53 and 54.

Instead, the ribs bands 57,58 are substantially arranged in specular relation to bands 61,60 relative to the midline 66 and band 59 comprises two half bands exactly specular as to the midline 66.

The advantages resulting from this arrangement will be explained in the following.

Figure 16 shows a second type of plate 67, equivalent to plate 21 of fig. 5, in the arrangement of ribs and opening.

Plate 67 has a size identical to the one of plate 51 and comprises a plurality of second kind ribs band 68,69,70,71,72 identically to bands 57,58,59,60,61 and identically located.

Plate 67 differs from plate 51 only for the reason that is not provided with ribs of the first kind, such as 52,53,54,55 in the spacing portions 73,74,75,76 corresponding to the spacing portions 62,63,64,65 of figure 15.

Plates of the first type only (figure 15), of the second type only (figure 16) or alternatively of the first and second type can be used to obtain heat exchangers having differing features and specifically meeting particular use requirements.

In particular:

Plates of the first type may be superimposed the one to the other to form a bank, with a 180° center rotation, among adjacent plates.

In this way the flat spacing portion 62 of one plate, superimposed to another one, overlays and contacts the top of rib 55 of the other plate and likewise the flat spacing portions 63,64,65 of the one plate respectively overlay and contact the top of ribs 54,53,52.

Thus a heat exchanger is obtained having a primary and sanitary circuit which circuits are identical each to the other and have a flow path in form of a meander in the plane of the plates.

It must be noted that in this case input and output of a circuit are located on the same side of the plate bank, relative to the midline 77 of fig. 15.

Within the meander flow path the ribs of the second kind of two adjacent plate cross to form a labyrinth.

This kind of exchanger features high pressure drops and very high thermal transfer efficiency (perfect flow countercurrent).

It is particularly suited for low flow rate application. Plates of the second kind, may be superimposed the one to the other to form a bank, with a 180° center rotation among adjacent plates.

A heat exchanger is obtained having two identical primary and sanitary circuits where the fluid flows from one opening of the plates to the opening specular as to the plate midline 78.

The flow turbolence is provided by the labyrinth formed by the second kind ribs, distributed in bands and crossing each other.

Thus kind of exchanger features very low pressure drops on both the primary and sanitary circuit and is particularly suited for high flow rates on both

circuits.

Plates of the first and second type may be superimposed the one to the other to form a bank, with a 180° center rotation among adjacent plates as to the showing of figure 15,16.

A heat exchanger is obtained having a primary circuit completely different from the sanitary circuit, and similar to the one described with reference to the use of plates such as those of figure 1 and 5.

This exchanger is particularly suited for application where very high thermal exchange efficiency must be obtained with a low pressure drop on the primary circuit.

Claims

1. A plate (21,67) for a plate-type heat exchanger, wherein a plurality of ribbed plates are juxtaposed and secured to one another to form a bank of chambers consisting of first and second sets of mutually adjacent chambers, the chambers of each set being communicated to one another by two sets of respectively inlet and outlet openings, each chamber of the first set being placed between two chamber of the second set except the end chambers in the bank, said plate (21,67) having a generic rectangular shape, a rim with two opposed side walls (155,56) of greater lenght and two opposed side walls of lesser lenght and four openings (22,23,24,25) located at corners of said plate (21,67), characterised in that said plate comprises:
   - a plurality (57,58,59,60,68,69,70,71,72) of sets of ribs extending in juxaposition one another and raised above one face of said plate and recessed below the other plate face, each set forming a band of ribs extending between said opposed side walls of greater lenght (155,56) at least one of said bands being spaced from adjacent bands by a spacing flat portion (62,63,64,65,73,74,75,76) of said plate extending from a side wall of greater lenght (155,56) towards the opposite one, said ribs being slanted relative to the direction of said greater lenght side walls (155,56).

2. A plate (51) as in claim 1 comprising a plurality of ribs (52,53,54,55) raised above one face of said plate and recessed below the other face plate, each rib extending in one of said flat portions (62,63,64,65) spacing said rib bands, alternately from one or the other of said side walls (155,56) of greater lenght to section of said flat portion intermediate to said side walls of greater lenght, so as to form a meander path in the plane of said plate.

3. A plate according to claim 1 or 2 wherein said ribs of at least a pair of adjacent bands (57,58,59,60,61,68,69,70,71,72) extend, at least in proximity of said flat spacing portion with slanting oriented in opposite direction from band to band, and transverse to the direction of the ribs in the other band of the pair.

4. A plate according to claims 1,2,3 wherein at leat said two side walls of greater lenght (155,56) of said rim are convex and form a cone-shaped surface for coupling of adjacent plates.

5. A plate-type heat exchanger wherein a plurality of ribbed plates are juxtaposed and secured to one another to form a bank of chambers consisting of first and second sets of mutually adjacent chambers, the chambers of each set being communicated to one another by two sets of respectively inlet and outlet openings, each chamber of the first set being placed betweentwo chambers of the second set except the end chambers in the bank, characterized in that said bank of chambers is formed by alternately juxtaposing plates of a first type (1,51) and a second type (21,67), the plates of the first type (1,51) being provided with a first plurality of parallel ribs (10,11,12,13,52,53,54,55) raised above one face of said plate (1,51) and recessed below the other plate face and being offset from one another which, on contacting a corresponding surface of a plate of the second type (21,67), form a meander chamber of a first type lying in the plane of said plates by juxtaposition of a plate of the second type (21,67) to the face with raised ribs of said first-type plate (1,51), and a chamber of a second type with no meander in the plane of said plates by juxtaposition of a plate of the second type (21,67) to the face with recessed ribs of said first-type plate (1,51), both plate types being provided with a second plurality of ribs (15,17,18,19,20,31,32,33,34,35) arranged likewise on either plate types, whereby on juxtaposing the two plate types in an order whatever said second plurality of ribs form a labyrinth chamber extending perpendicularly to the plane of said plates.

6. A heat exchanger as in Claim 5, wherein said surface of contact with said first plurality of ribs is the flat surface of said plate of the second type.

7. A heat exchanger as in Claim 5, wherein said surface of contact with said first plurality of ribs is the tip of a third plurality of raised ribs on said *second-type* plate projecting in the opposite direction from that of said first plurality of ribs.

8. A heat exchanger as in claims 5,6,7, wherein said second plurality of ribs comprises a first set (17) of elongate ribs extending in a transverse direction to the direction of flow through said meander chamber.

9. A heat exchanger as in Claim 8, wherein said second plurality of ribs comprises a second set (19) of elongate ribs extending in the direction of flow through said meander chamber.

10. A plate (1,21,51,67) for a plate-type heat exchanger wherein a plurality of ribbed plates are justaposed and secured to one another to form a bank of chambers consisting of first and second sets of mutually adjacent chambers, the chambers of each set being communicated to one another by two sets of respectively inlet and outlet openings, each chamber of the first set being placed between two chamber of the second set except the end chambers in the bank, said plate (21,67) having a generic rectangular shape, a rim with two opposed side walls (155;56) of greater lenght and two opposed side walls of lesser lenght and four openings (22,23,24,25) located at corners of said plate (21,67), characterised by that at least said pair of opposed side wall of greater lenght (155,56) of said rim are convex and form a cone-shaped surface for coupling among adjacent plates.

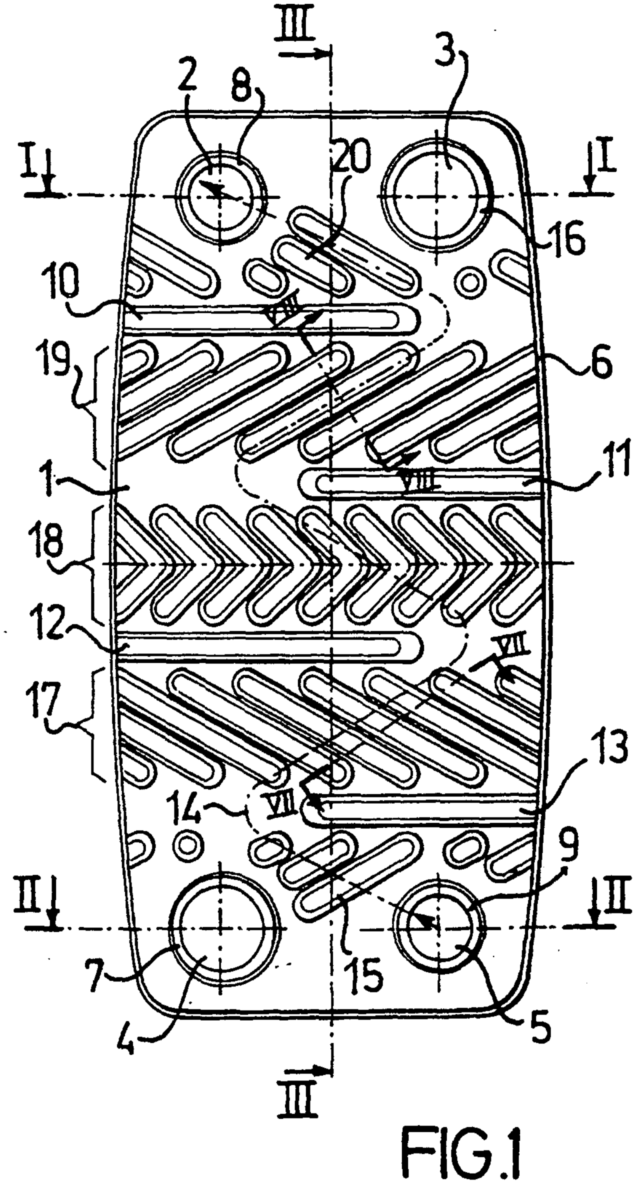
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FIG.1

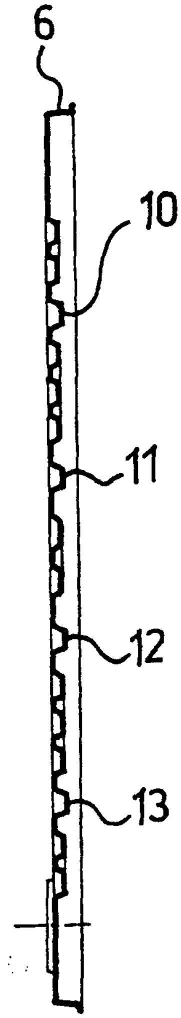
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FIG.4

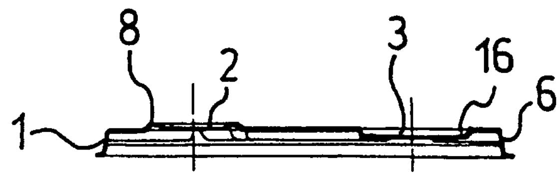


FIG.2

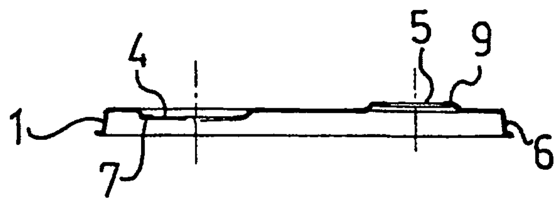


FIG.3

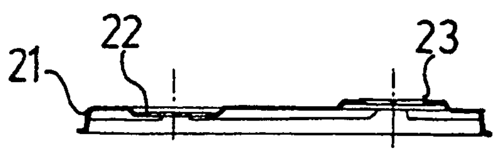


FIG.6

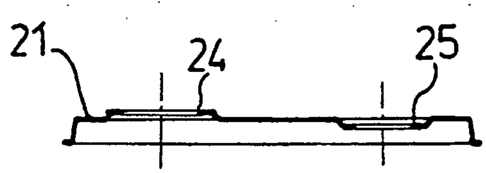


FIG.7

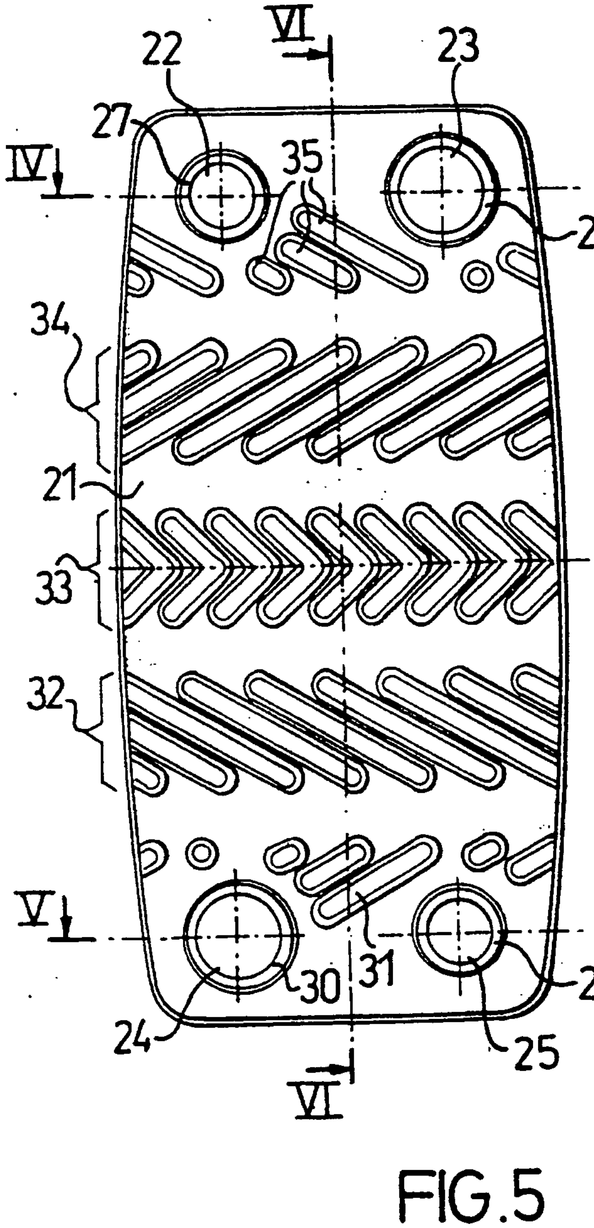


FIG.5

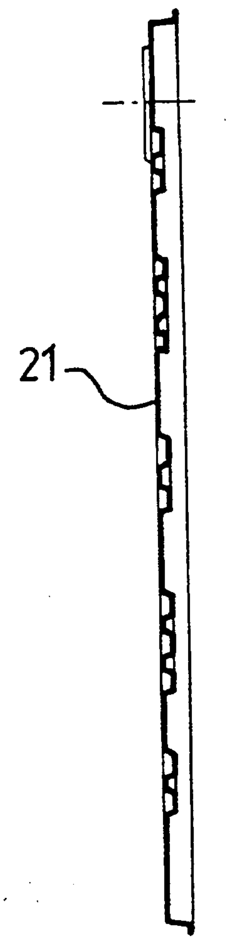
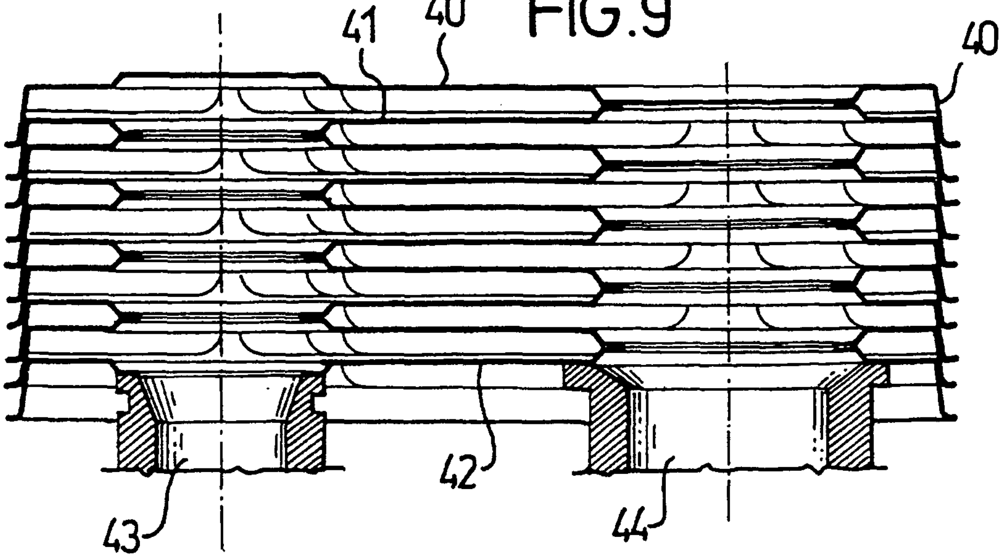


FIG.8

FIG.9



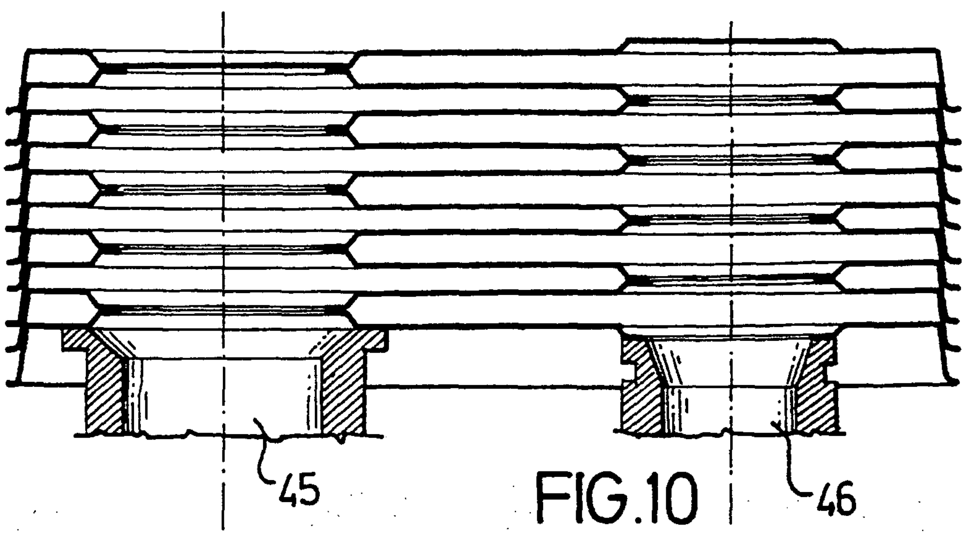


FIG.10

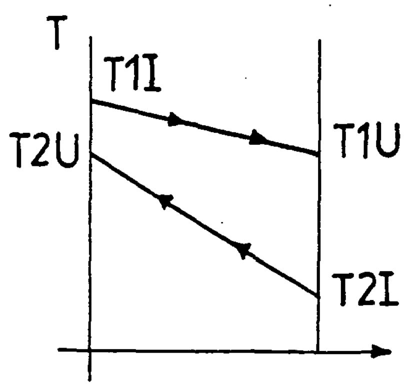


FIG.14

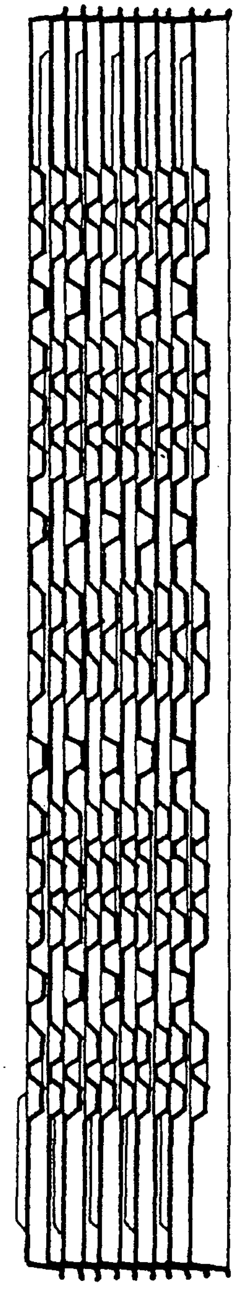


FIG.11

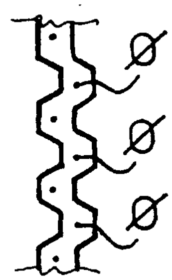


FIG.12

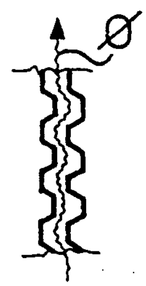


FIG.13

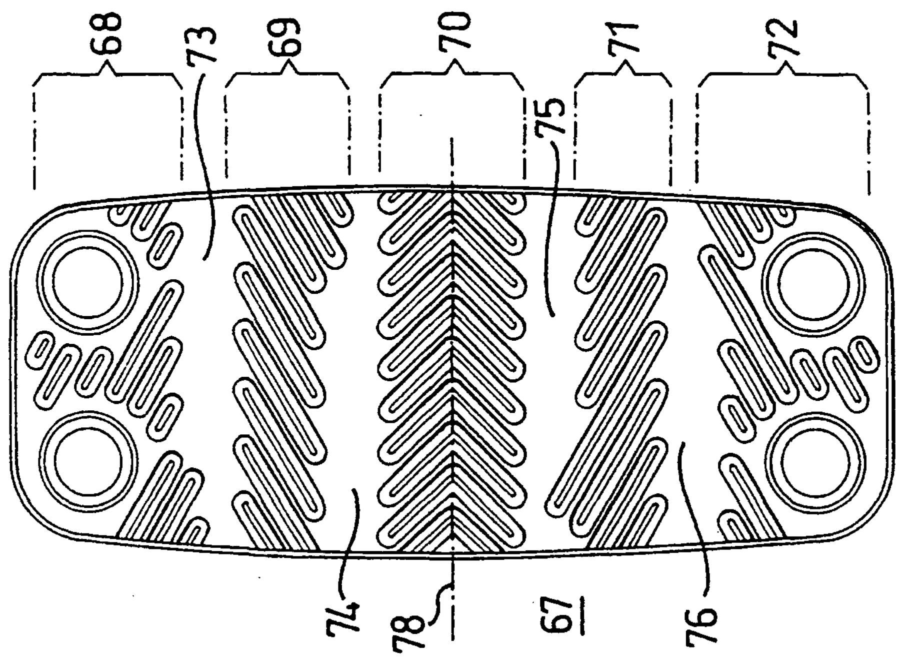

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FIG.16

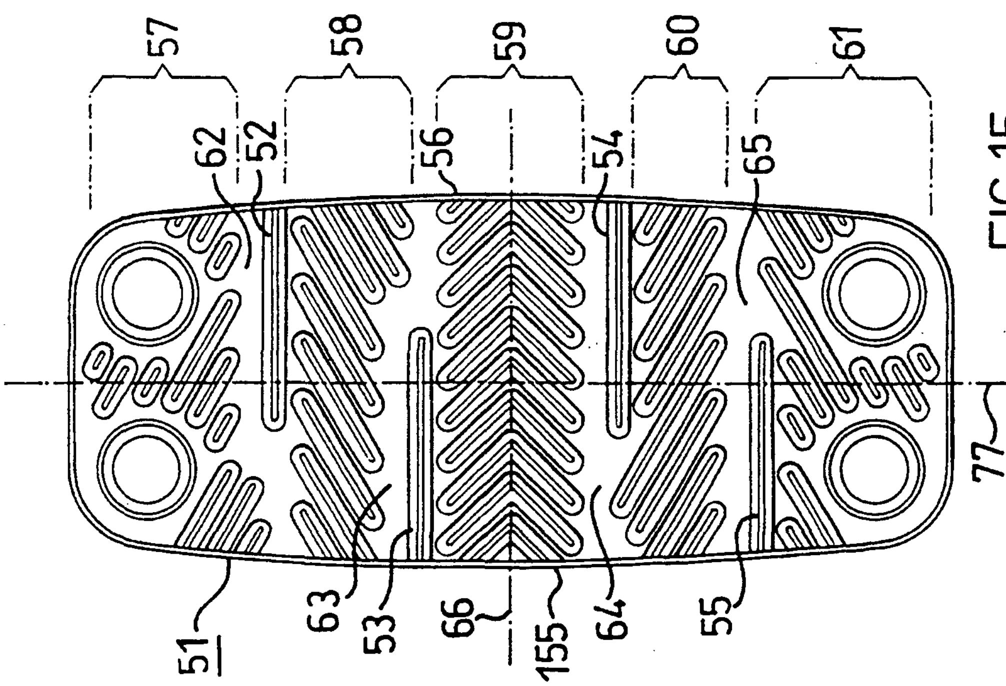
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FIG.15